DOLKART

Experiments in Wireless Telegraphy

Electrical Engineering
B. S.

1903

EXPERIMENTS

IN

WIRELESS TELEGRAPHY

BY

LEO DOLKART

THESIS FOR DEGREE OF BACHELOR OF SCIENCE

IN ELECTRICAL ENGINEERING

COLLEGE OF ENGINEERING

UNIVERSITY OF ILLINOIS

PRESENTED JUNE 1903

UNIVERSITY OF ILLINOIS

June 1, 1903 190

THIS IS TO CERTIFY THAT THE THESIS PREPARED UNDER MY SUPERVISION BY

LEO DOLKART

ENTITLED EXPERIMENTS IN WIRELESS TELEGRAPHY

IS APPROVED BY ME AS FULFILLING THIS PART OF THE REQUIREMENTS FOR THE DEGREE

OF Bachelor of Science in Electrical Engineering.

Morgan Brooks

HEAD OF DEPARTMENT OF Electrical Engineering.

I N D E X.

The author's own work chiefly consisted in experimenting with the different forms of coherers using different systems and in attempting, if possible, to devise a simple form of a coherer and some simple and positive operation of decohering device. Most of the tests were conducted between two rooms opening into each other, the apparatuses being at a distance of about 40 ft. from each other. If time permits it is the intention to make some distance tests.

In the first experiments an induction coil of half an inch spark was used. In the later tests a 500 Watt Westinghouse transformer No. 108600 was substituted for the induction coil. The primary of the transformer received current at 100 Volts, reduced from the lighting circuit of 110 Volts by means of a water rheostat, and gave out at the terminals of the secondary 10000 Volts. For the sparking terminals an oscillator with three fourths of an inch brass balls and on fourth of an inch spark gap was used. A condenser connected in parallel accross the spark gap, was composed of two one eightof an inch glass plates covered with tin foil. A Kelvin electrostatic voltmeter No. 300 was used in measuring the secondary voltage.

SENDING STATION

RECEIVING STATION

3 RECEIVING INSTRUMENTS
WITH TRANSFER KEYS

RECEIVING STATION OF
DE FOREST SYSTEM

In the true sense of the word there can be no wireless telegraphy, for one cannot conceive of an electric apparatus that has no wires whatever. Wires must be used in relays, windings and as base lines. What is really meant by wireless telegraphy is, that there are no wires or cables between the sending and receiving stations along which communications are sent. Airography, as suggested by some journals, or space telegraphy are more appropriate terms.

There are three methods by which communication can be made in space telegraphy*. They are

1. Conduction Method
2. Induction Method
3. Wave Method.

In the conduction method, first introduced by Willoughby Smith in 1887, the ground is used as the medium along which the signals are sent. Not very much has been accomplished with this method of signaling.

In the induction method the effect of two circuits, one upon the other, is made use of. Preece in 1892 was able by means of electrodynamic induction to communicate between ships at sea and land. A line of wire was constructed along land equal in length to the windings on board each ship. Edison in 1892 obtained a patent on a method of communication according to the laws of electrostatic induction between two separate but parallel wire circuits. Both of the above methods, in the present state of the science, are not of much account.

* Dr. N. Blockman "Telegraphie Ohne Drath" Page 7.

The third method, communicating by means of waves, is receiving most attention at present. The wave method is subdivided into two classes: communication by means of the Hertzian waves as used by Marconi, Fessenden, De Forest, Popoff, Slaby and Arco, Braun and others; and by means of the ultra violet rays as used by Zickler. Both of these systems bear a close relation to each other due to the indentity of electrical and light forms of energy. At present the greatest progress has been made by Sig. Marconi. Using the Hertzian waves, he established communication between Cornwall and Newfoundland, a distance of over 2000 miles.

The Hertzian waves first discovered by Dr. Hertz in 1888, are able to set up similar waves in nearby bodies" provided these bodies are of such electrical capacity as to be able to vibrate electrically at the same rate as the body which emitted them."* From this is seen the importance of syntonizing the apparatus at the stations and upon this principle dpends the commercial success of space telegraphy. For if a third station can successfully receive communications not intended to be sent to it, orcan disturb the atmosphere so as to prevent the the second station from receiving its message, space telegraphy for commercial purposes is not feasible.

The most important single piece of apparatus of the whole system is the coherer, the principle of which was first discovered by Prof. Hughes in 1879. Its theory is very simple.

* L. R. " Space Telegraphy" P. 29.

The coherer is a devise which will allow a direct current to pass only after responding to Hertzian waves. This direct current may be used to actuate a telephone or a telegraph relay. The first coherers devised, usually contained metal filings between two electrodes or terminals in a sealed tube. The unusually high resistance of the filings prevents any appreciable current from flowing until the Hertzian waves break down this resistance, as if by making these filings cohere, whence the name coherer. Unless tapped, the coherer continues to show low resistance although the Hertzian waves cease. When a direct current passes through the coherer, the relays or telephones are actuated and a signal can be distinguished, but in order to receive the successive signals necessary to a message, the coherer must be promptly decohered or restored to its original high resistance. This is commonly effected by an electrical tapping device.

The first practical filings coherers were devised by Prof. Branly in 1891. As no patents were applied for by Branly, the principle of his coherers has been extensively used over all the scientific world. The great objection to the Branly coherer is the necessity of decohering it. If a vibrating armature, such as the tapper of an electric bell, is connected in a direct current circuit passing through the coherer, it can be placed so as to strike the coherer tube and restore it quickly to its normal high resistance. Any such mechanical method of decohering requires however, an appreciable time for action and so limits the rapidity of transmission.

There are two distinct types of coherers: * coherers or

* Collins, Scientific American, Oct. 4' 02

[illegible]

The first practical filling machines were [illegible]

[illegible]

detectors which depend in their working upon the increase and decrease of resistance of their parts; and magnetic detectors which depend upon the increase and decrease of the magnetic permeability of some of their parts. The first class of coherers usually are not, while the second class usually are self-decohering or self restoring.

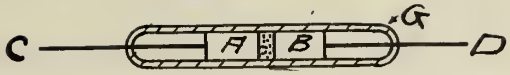
An example of the first class of coherers is the Branly coherer (Fig. 1). A and B are german silver plugs terminating in the line wires C. and D. and tightly fitting the glass tube G. The space between A. and B. is filled with slightly amalgamated nickel and iron filings. The space between the plugs is first adjusted for sensitiveness and the coherer is then exhausted and sealed. The Castelli coherer (Figs. 2 and 3), claimed to be self-restoring, is composed either of carbon or iron plugs instead of german silver and contains mercury instead of metal filings. A modification of the Castelli coherer, called the "Royal Italian Navy" (Fig. 4), has lately been used by Marconi in his transatlantic communications.

As was stated before the older form of a Branly coherer must be decohered mechanically. The new form of a Branly coherer or detector is self-restoring. This detector is composed of a metal disc A (Fig. 5) fixed to these metal rods BBB whose free ends are oxidized. These ends rest on a polished plate c. The variable resistance between the oxidized points and the polished plate serve the same functions as the filings.

Schaefer * substitutes for a coherer a glass plate

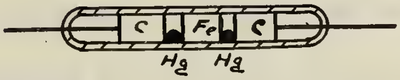
* Electrical World and Engineer, July 14'02.

FIG. 1



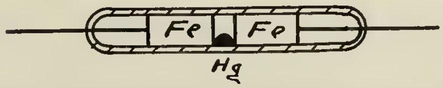
BRANLY COHERER

FIG. 2



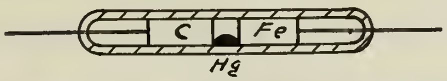
CASTELLI COHERER.

FIG. 3



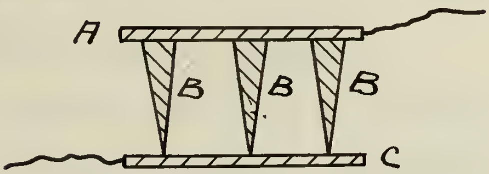
CASTELLI COHERER.

FIG. 4



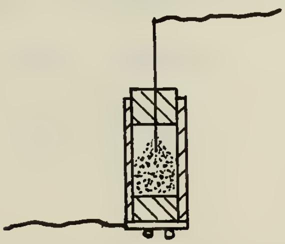
ROYAL ITALIAN NAVY

FIG. 5



BRANLY DETECTOR

FIG. 6



CERNY COHERER

covered with a metallic coat which is cut or scratched into minute parts by finely pointed tool. When the plate cohers the waves seem to arc across these scratches and lower the resistance of the plate from about 5000 to about 50 Ohms.

Marconi has made a very simple form of a magnetic detector which was originated by Prof. Elihn Thomson. Two * sets of windings are wound on a core of thin iron wires. One set is connected to an aerial wire and the ground, the other to a telephone receiver. At one end of the core a magnet is caused to revolve slowly. The slow change in lines of force through the core allows the impinging Hertzian waves to be recorded in the telephone receiver (Fig. 8).

The detector of Prof. Fessenden** for which a patent has just been granted, consists of a silver wire having a platinum core. The wire is looped and by dissolving the silver from the loops, the platinum is left exposed. The loop is finally mounted in an exhausted silver shell. This detector is called a "current responsive device" (Fig 9).

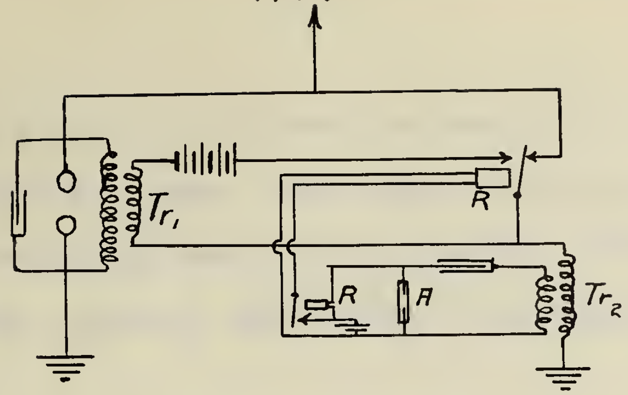
In the Bell***system the signals are sent as a series of wave impulses having certain intervals of time. The advantage claimed for the system is that messages can overlap each other.

* London Electrician, July 18'02.

** Scientific American, Jan. 3'03.

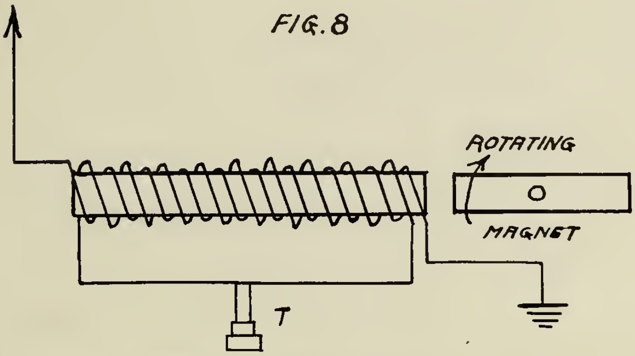
*** London Electrician, Jan. 2'03.

FIG. 7



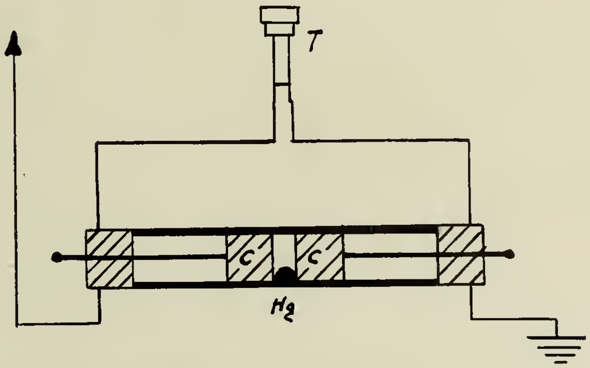
GUARINI REPEATER

FIG. 8



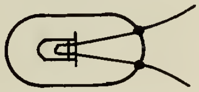
MARCONI DETECTOR

FIG. 9



CASTELLI COHERER

FIG. 10



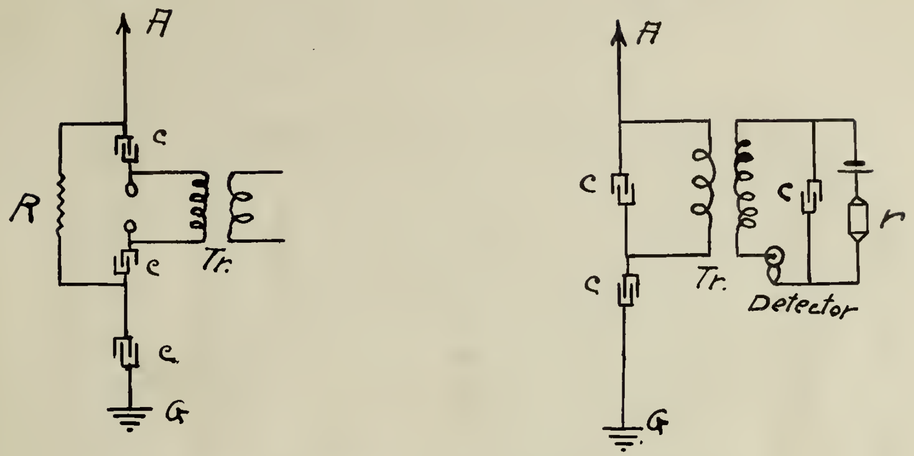
FESSENDEN CURRENT RESPONDER

The methods of connection used in the different systems are practically the same. The small differences are usually found in the receiving cicuit arrangements. The accompanying diagrams illustrate some of the different systems.

Lond. Elect. March 27'03.

FIG. 11

FIG. 12



CLOSED SENDING & RECEIVING CIRCUITS

LODGE-MUIRHEAD SYSTEM.

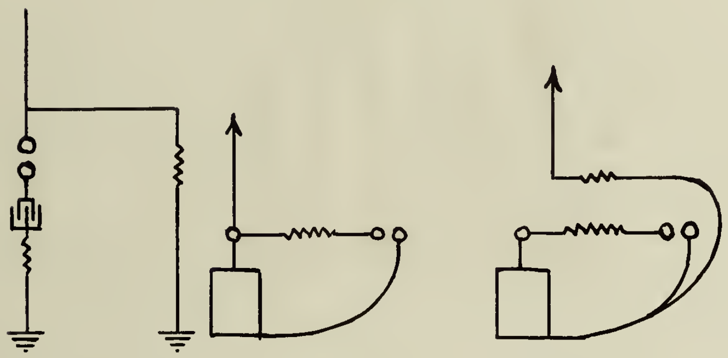


FIG. 13

FIG. 14

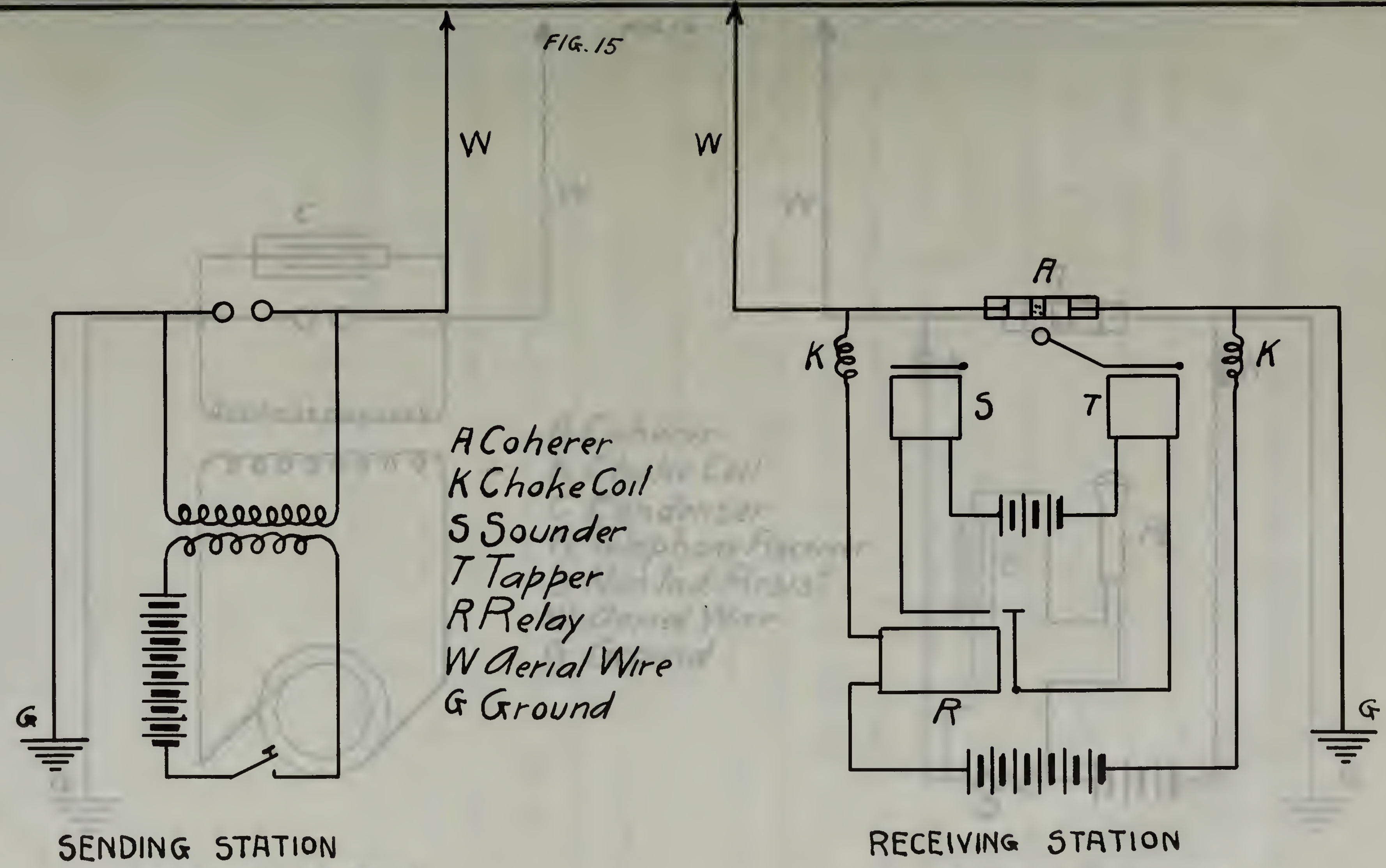
DIFFERENCE BETWEEN SLABY & BRAUN TRANSMITTERS

FIG. 13 - SLABY TRANS.

FIG. 14 - BRAUN TRANS.

Lond. Elect. Review, March 20'03

FIG. 15



MARCONI SYSTEM

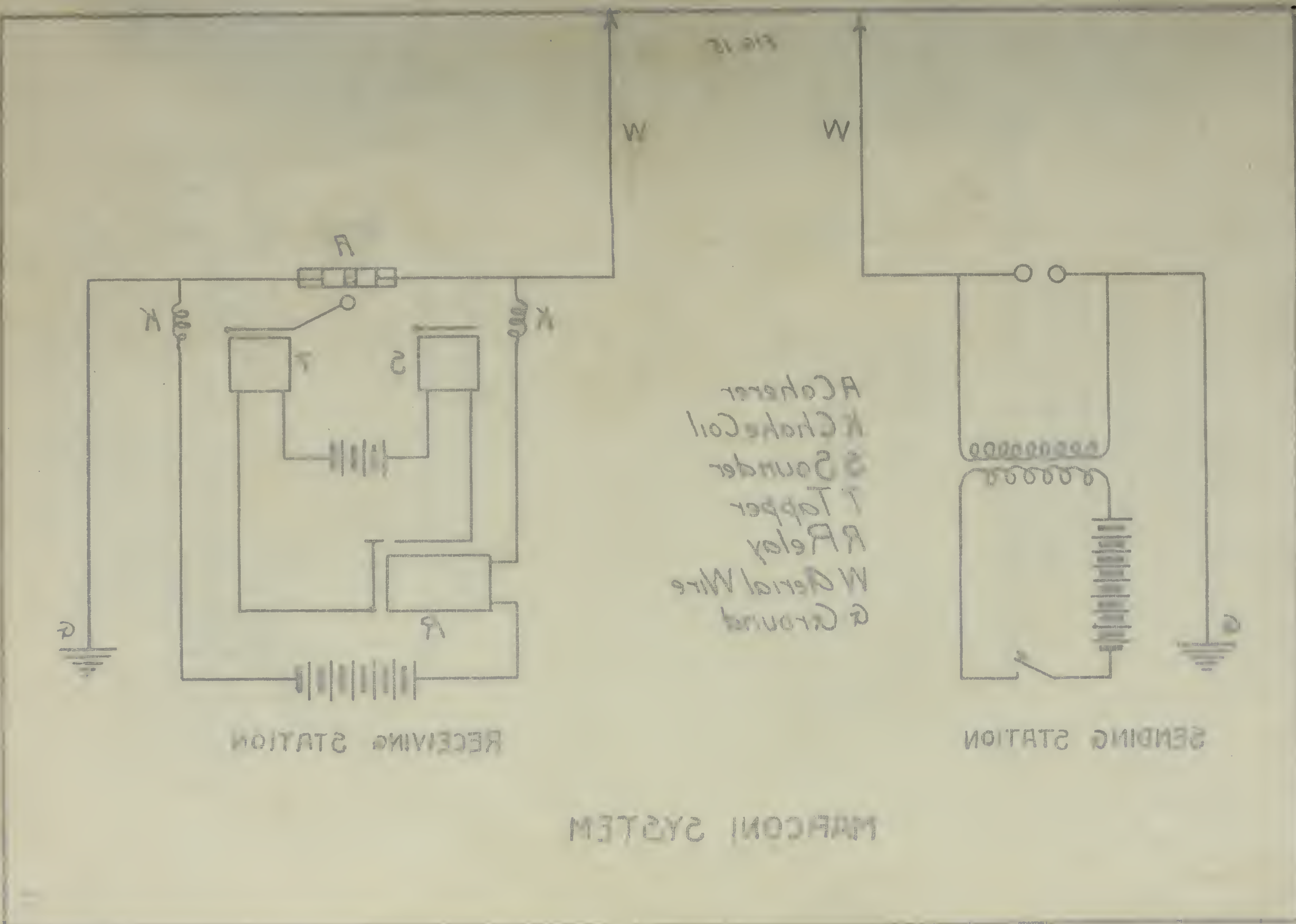
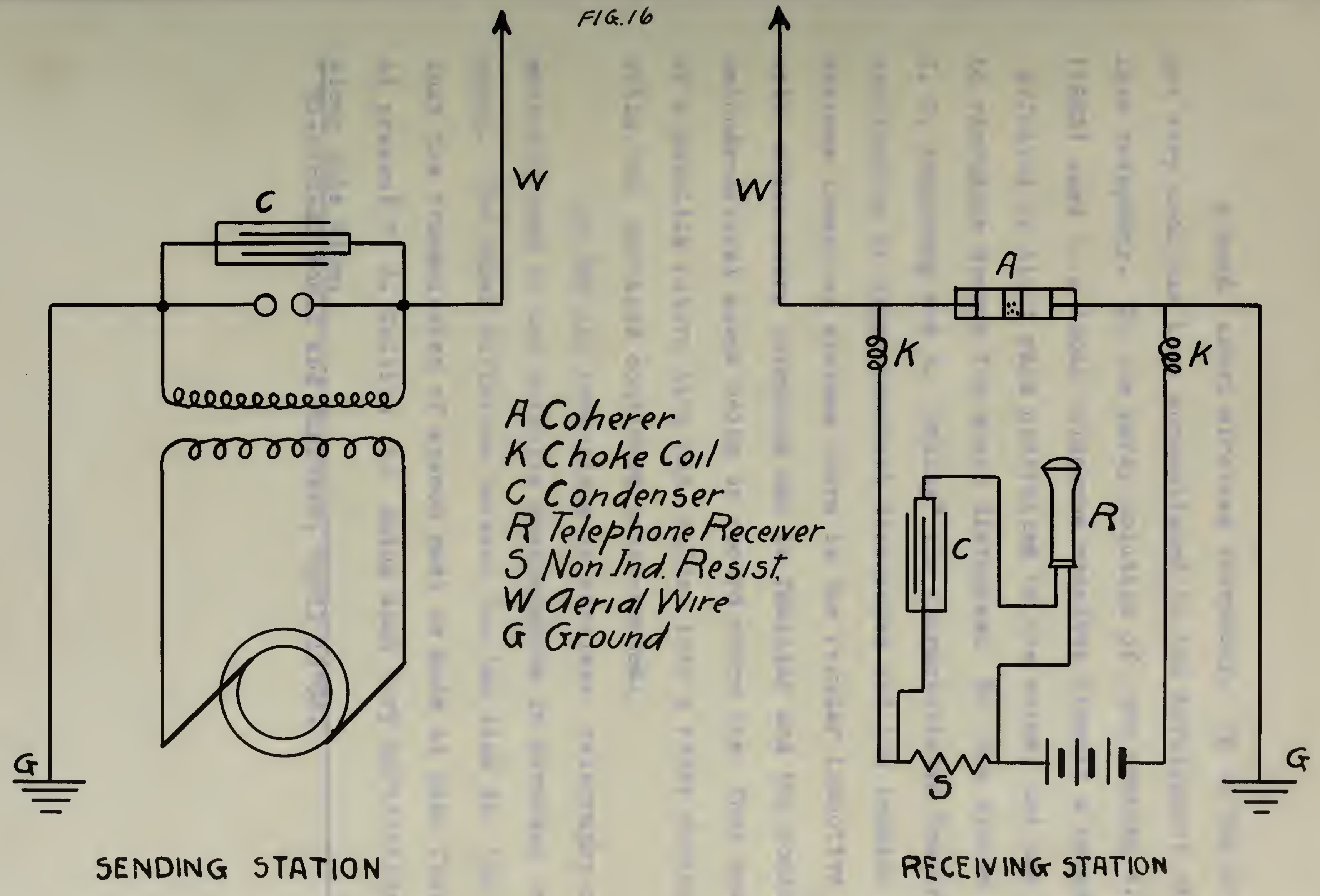
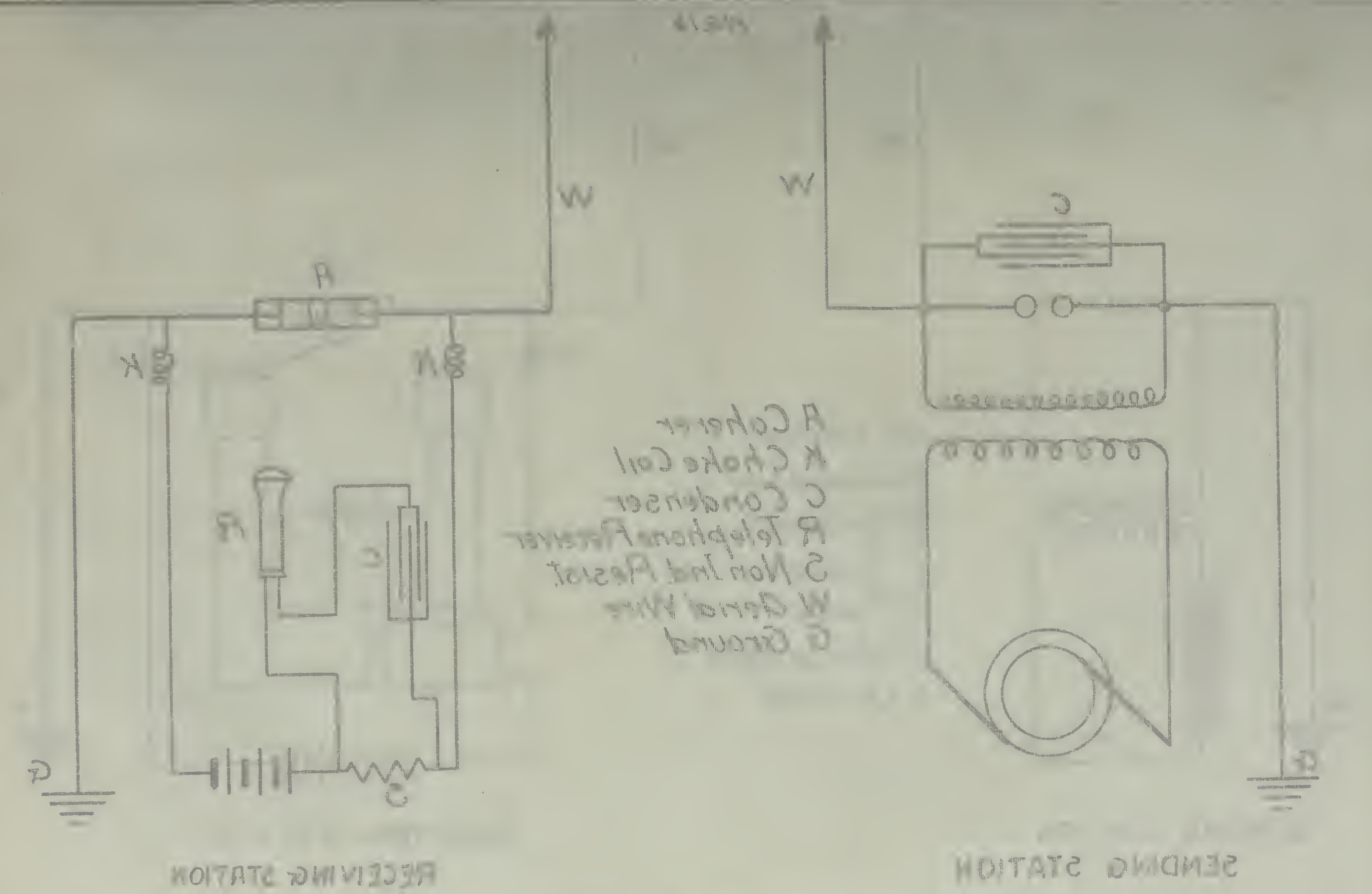


Fig. 18
W
W
A
K
K
T
S
R
G
G
A Coherer
K Choke Coil
S Sounder
T Tapper
R Relay
W Aerial Wire
G Ground
RECEIVING STATION
SENDING STATION
MARCONI SYSTEM

FIG. 16



DE FOREST SYSTEM



DE FOREST SYSTEM

A word about wireless telephony. Up to the present not very much has been accomplished in the development of wireless telephony. In the early solution of the problem A.G.Bell (1883) used in a local telephone receiver circuit a relenium cell, affected by light rays controlled by the voice, and has been able to reproduce speech for short distances. In the system used by J. F. Armstrong and A. Orling* the characteristic feature is the combination of high potential discharges and low tension currents. Besides these two systems there is the regular inductive method, with which every telephone man is familiar and the conductive method--several cases being on record where the four broken ends of a metallic return line had fallen into a river during a storm while the services continued uninternpted.

So far all inventions in wireless telegraphy can scarcely lead to any definite developments in wireless telephony. The chief differnce between the two lies in the fact that the transmission of speech must be made at high frequencies. At present F. A. Collins is doing some very meritorious work along this line.

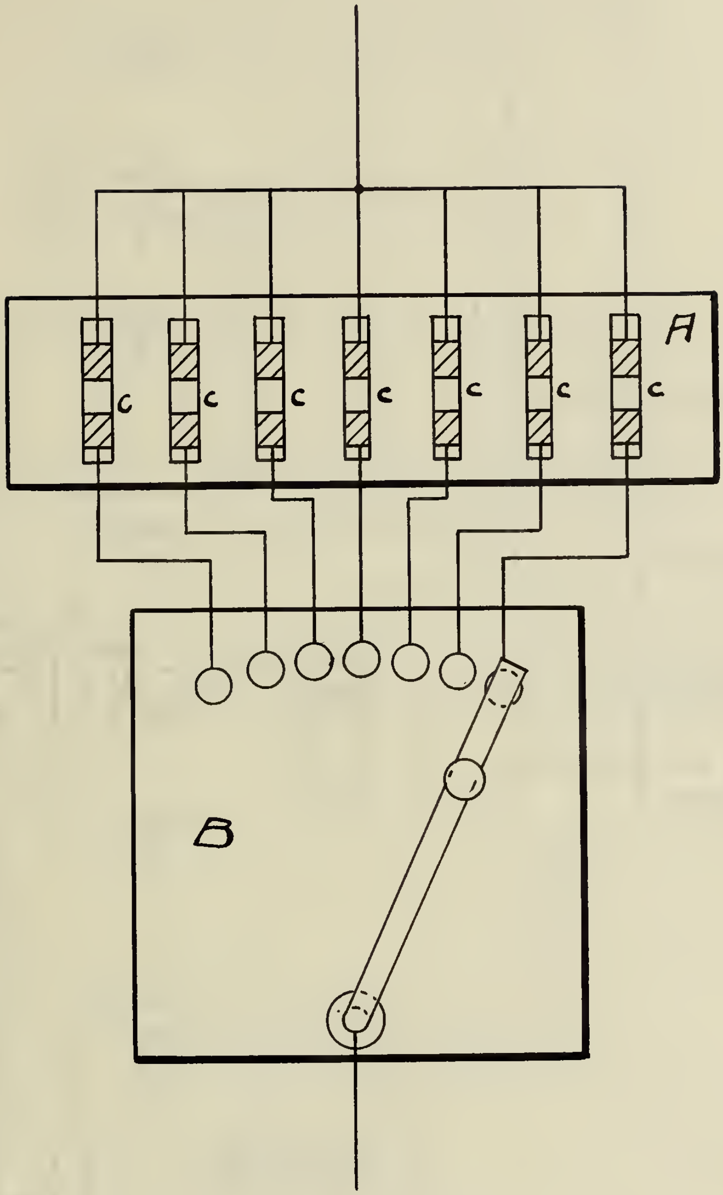
* Electrical World and Engineer, April 18'03.

The following data show the results obtained with the various coherer using various systems of connections.

All coherers were sealed with sealing wax in order to keep out the moisture and permit delicate adjustments.

In general it may be said that for the short distances tried there was no difference in the operations of either the Marconi or DeForest systems. The slight objection to the DeForest system using a condenser is the necessity of always holding a receiver to ones ear.

FIG. 17



TRANSFER SYSTEM.

CONNECTIONS USED IN TRANSFERING DIFFERENT COHERERS TO THE RECEIVING CIRCUIT

A- COHERER BOARD   B - TRANSFER BOARD   C- COHERERS

CONNECTIONS USED IN TRANSFERING RECEIVING CIRCUIT TO DIFFERENT SYSTEMS.

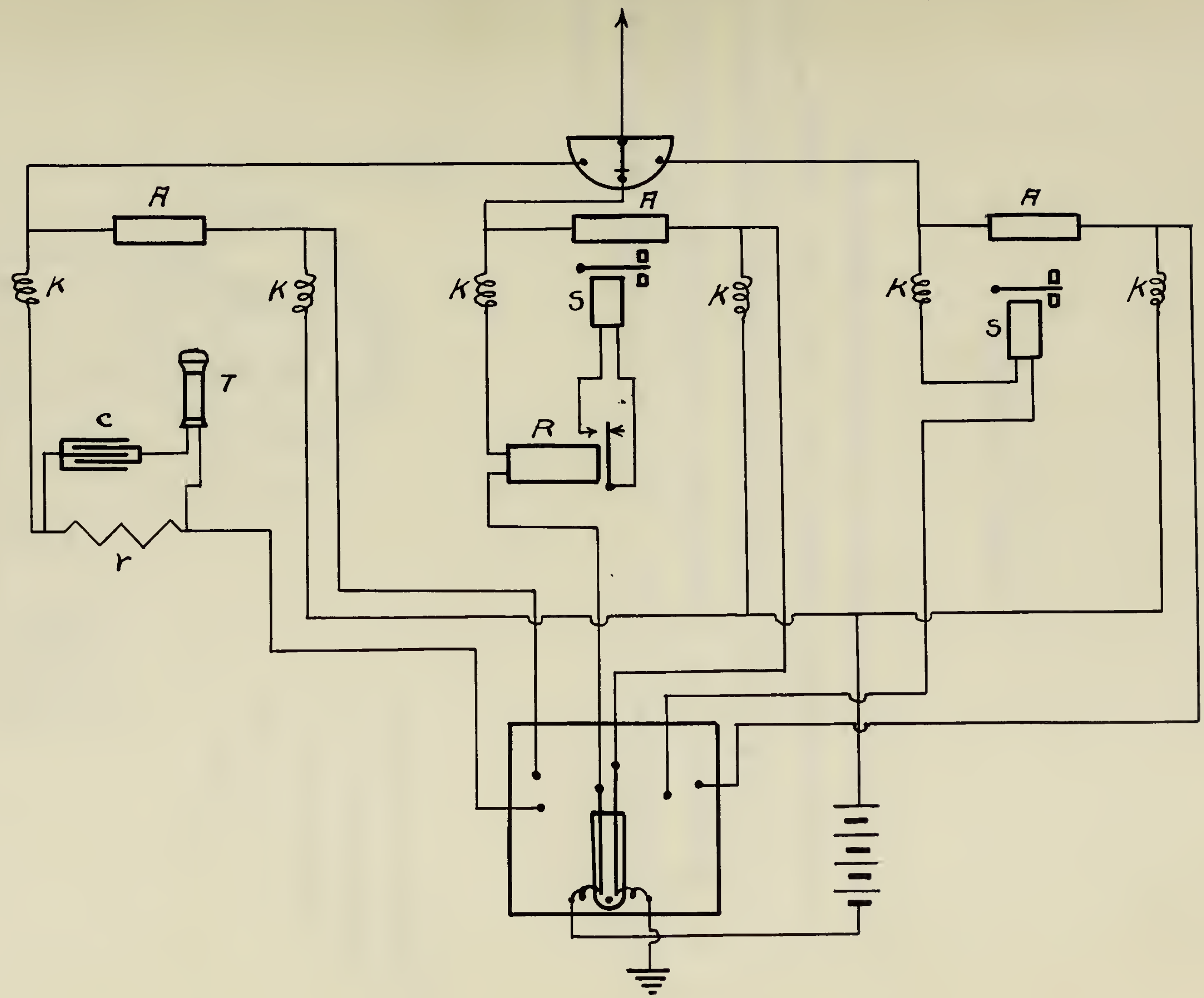


FIG. 18

MAGNETIC DETECTOR.

The dynamo produces a continuous vibration in the telephone (FIG) but when the Hertzian waves impinge on the vertical wire the conductivity between the ring B and the wedges is changed and the change is recorded in the telephone. In the author's experience the detector did not always work satisfactorily.

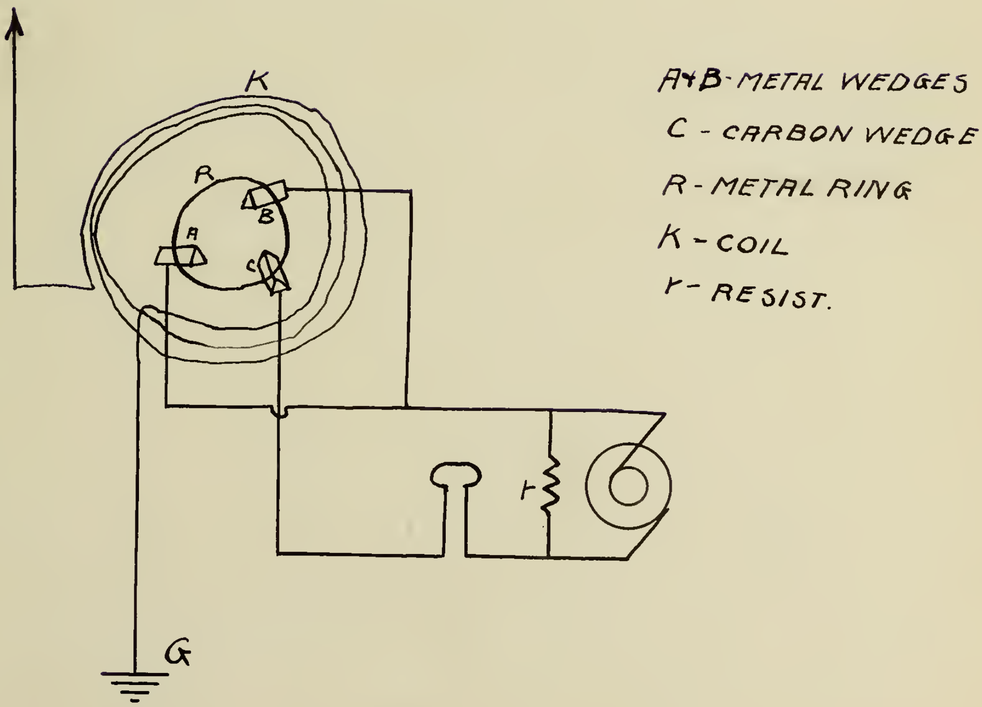


FIG. 19

BRANLY COHERER NO. 1.

Filings---Nickel 5%, Iron 95%

Glass Tube---1/4" diameter.

Plugs---Copper----3/16 in. diameter.

Average distance between plugs---1/8 in.

Marconi and De Forest Systems.

Operation:-

This coherer worked quite satisfactorily. The only trouble found with it was in decohering it--quite a powerful stroke was found necessary. All forms of automatic tapping devices failed to give the coherer a sufficiently powerful stroke. The sensitiveness of the coherer was quite low.

BRANLY COHERER NO.2.

Filings---iron---few.

Glass Tube---3/8 in. diameter.

Plugs---copper---5/16 in. diameter.

Average distance between plugs---1/8 in.

Marconi and De Forest Systems.

Operation:-

The coherer had periods of satisfactory working. When it did work successfully, a powerful stroke of the hand was necessary to discoher it. The periods of inconstant working were of such often occurrence, that this coherer could not be depended upon.

BRANLY COHERER NO. 3.

Filings---iron.

Glass Tube---1/4 in. diameter.

Plugs---brass---3/16 in. diameter.

Average plug distance---1/8 in..

Marconi and De Forest Systems.

Operation:-

The coherer worked at first very well but after a time no amount of adjustment could bring it back into working condition. The coherer worked especially well with the De Forest System. In the latter system, ten or twelvesuccessive signals could be distinguished in the telephone receiver before it would be necessary to tap the coherer.

BRANLY COHERER NO. 4.

Mercury used instead of filings.

Glass tube---1/4 in. diameter.

Plugs---brass---3/16 in. diameter.

Average distance between plugs---1/8 in.

Marconi and De Forest Systems.

Operation:-

The coherer would seldon work. The contact between the mercury and the plugs did not seem sensitive enough to respond to the Hertzian waves. The plug distance varied from 1/16 in. to 1/4 in.

BRANLY COHERER NO. 5.

Filings---iron---many.

Glass tube---11/32 in. diameter.

Plugs---brass---9/32 in. diameter.

Average distance between plugs---1/4 in.

Marconi and De Forest Systems.

Operation:-

The coherer would seldom work . A conclusion derived from this class of coherer is, that the larger the internal diameter of the tube the less the sensitiveness of the coherer.

BRANLY COHERER NO. 6.

Filings---iron--and small drops of mercury---few.

Glass tube---1/4 in. diameter.

Plugs brass---3/16 in. diameter.

Average distance between plugs 1/2in.

Marconi and De Forest Systems.

operation:-

With small distance between the plugs, the coherer would work satisfactorily, but with an increase of the distance the sensitiveness decreased. A conlusion derived in regard to these coherers is, that with an amount filings equal to 1/4 the volume of the space between the plugs, other things being equal, the coherer is at maximum sensitiveness.

BRANLY COHERER NO. 7.

Filings---iron and small drop of mercury---few.

Glass tube 1/16 in. diameter.

Plugs--german silver wire in. diameter.

Average distance between plugs---1/8 in.

Marconi and De Forest Systems.

Operation:-

In this coherer the filings were very few in number--just sufficient to form a line between the wire plugs. The coherer would not work.

BRANLY COHERER NO. 8.

Filings---iron and small drop of mercury---tube full of filings.

Glasstube---3/16 in. diameter.

Plugs---german silver wire- .058 in. diameter.

Average distance between plugs---1/4 in.

Marconi and De Forest Systems.

Operation:-

This coherer worked satsifactorily with either system. In the De Forest system signals could be definitely distinguished every time without tapping the coherer. After twenty or thirty signals the coherer would reach a very low sensitiveness and a tap would be necessary to restore it to its original condition.

CASTELLI COHERER NO. 1.*

Mercury used instead of filings.

Glass tube ---11/32 in. diameter.

Plugs---carbon---9/32 in. diameter.

Average distance between plugs---1/4 in.

Marconi System.

Operation:-

This coherer is claimed to be self restoring . The author's experience showed the coherer to be too sensitive. When once started in operation it would continue to operate the relay several times after each signal---due to the one received signal. After a time it became inoperative.

* London Electrical Review July 11-18,'03.

CASTELLI COHERER NO. 2. *

Mercury used instead of filings.

Glass tube ---7/16 in. diameter.

Plugs---iron--3/8in. diameter.

Average distance between plugs---1/8 in.

Marconi System.

Operation:-

The coherer operated for a time successfully. It decohered itself as was claimed by its inventor. The author's trouble with it was in trying to keep the same relative distance between the outer and inner segments. After a few signals the the middle segment would move out of adjustment and the coherer so lose its sensitiveness.

* London Electrical Review, July 11-18,'03.

MODIFICATION OF CERNY COHERER.

Filings---iron.

Glass tube---11/32 in. diameter.

Plugs---magnetized sewing needles.. .

Marconi System.

Operation:-

The modified coherer differs from the original Cerny* coherer in, that the latter has only one magnetized needle terminal while the modification has two. FIGS. and show the original and the modified coherers.

The coherer was mounted on the lever of an ordinary line sounder. By adjusting the lever of movements of the sounder, a position can be found where the coherer would decohere every-time the lever falls. The magnestized needles attract "brushes" of filings and these offer sufficient resistance to prevent the passage of the local direct current, but have sufficient conductivity for the Hertzian waves. After each passage of the waves more particles are attracted to the needles. and brushes. The direct current is enabled to pass, the relay and sounder are actuated and the superfluous brush particles fall off with the downward movement of the sounder lever. Now the coherer is in a position to again receive the Hertzian waves and so continue the process.

*American Electrician Jan. '03.

DOLKART COHERER.

Filings---95% Aluminum and 5% iron.

Plugs---magnetized sewing needles.

Marconi System.

Operation:-

Like the modification of the Cerny Coherer, this one was also mounted on a sounder lever.

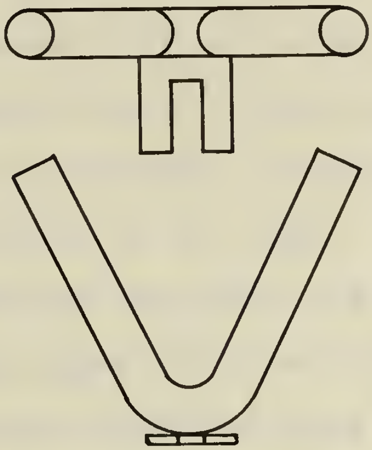
The U form was adopted instead of Cerny's straight tube for the reason that in enabled much more delicate adjustments. The needles N,N, were soldered to screws S,S, moving in threaded plates P,P. The two plates P,P, were held to the tube by means of sealing wax. The object of having the needles soldered to screws was to obtain very delicate adjustments. The needles were of a sufficient height above the filings to attract small "brushes. The needles were not very strongly magnetized.

The coherer worked very satisfactorily at the distance, of 12 metres (40ft). The speed of receiving signals for this coherer seems to be limited to about 15-20 per minute-with speeds beyond this the coherer "sticks" i.e. fails to be decohered by the sounder lever. A decided time interval was observed between the sending and the response of the receiving instruments.

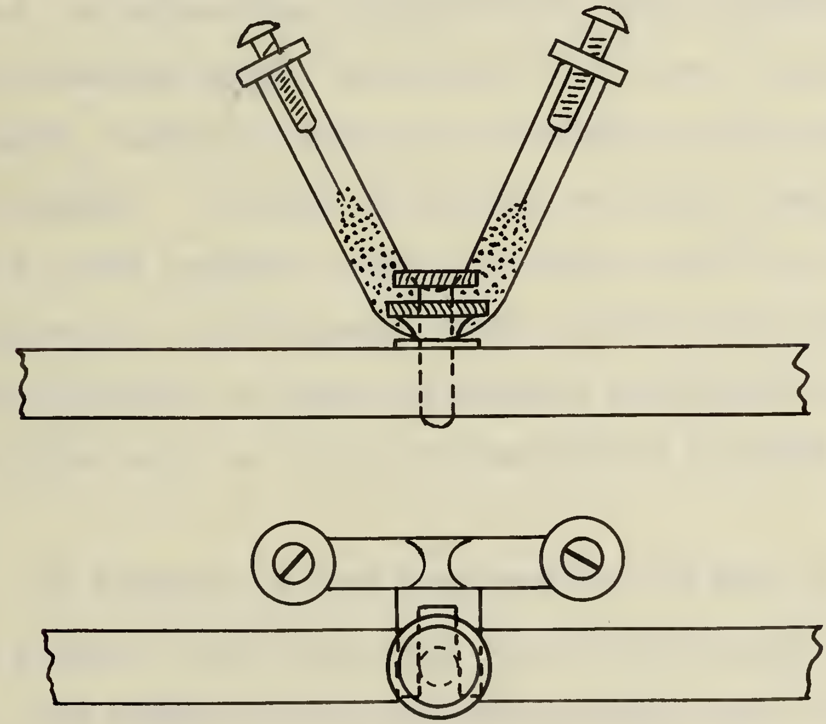
Several coherers were made of this type and all proved very satisfactory.

DOLKART COHERER

ADJUSTING SCREW – NUT HELD TO TUBE
BY SEALING WAX



COHERER AND METAL BASE HELD
TOGETHER BY SEALING WAX



VIEWS SHOWING COHERER
MOUNTED ON SOUNDER LEVER

Space telegraphy is unlikely to supercede wire telegraphy for all purposes. It has a peculiar field of its own. More good can be accomplished in the end if the line and space telegraph companies co-operate with each other. To illustrate this point, these are several lines in Alaska where owing to the severe storms a lineman must be stationed the year round at about every twenty-five or thirty miles of the line. In such places space telegraphy has a peculiar advantage and at present one line company is substituting space for line telegraphy in the district mentioned. Another great field for space telegraphy lies in communicating between ships and the shore and between ships at sea.

Unless very great improvements are made in selective systems and in preventing interference from outsiders the outlook for commercial space telegraphy is not very brilliant. Brokers could hardly be expected to send out their market quotations by means of space telegraphy with the knowledge that competitors might receive these quotations and at the same time remain unknown to the brokers. Naval warfare can perhaps show the greatest application of space telegraphy provided the system can offer positive and at the same time secret methods of communication.

At present no long messages can be sent or received unless by constant repetition and requiring constant adjustment of coherers. The speed at which communications are at present sent is at the rate of about ten to fifteen words per minute. The power required to transmit signals at long distances varies with

the distance. Marconi, in his transatlantic messages, used at first about two hundred horse power at the sending station but with improved apparatus this has been reduced to about fifty horse power. Further reduction in power may be expected, but the cost of fifty horse power is insignificant in comparison,to the advantage of a telegraph "line " without wires.

The development in wireless telegraphy very aptly illustrates how the practical is derived from the purely theoretical and scientific discoveries. All progress in space telegraphy has been made by the union of theory and practice. This alone shows that the two are not separate in their aims.

If as much can be accomplished in space telegraphy in the next few years as has been done in the last few, the outlook for space telegraphy is very bright indeed.